

Review

Year in review 2006: *Critical Care* - resource management

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Abstract

As health care resources become increasingly constrained, it is imperative that intensive care unit resources be optimized. In the years to come, a number of challenges to intensive care medicine will need to be addressed as society changes. Last year's *Critical Care* papers provided us with a number of interesting and highly accessed original papers dealing with health care resources. The information yielded by these studies can help us to deal with issues such as prognostication, early detection and treatment of delirium, prevention of medical errors and use of radiology resources in critically ill patients. Finally, several aspects of scientific research in critically ill patients were investigated, focusing on the possibility of obtaining informed consent and recall of having given informed consent.

Introduction

During 2006 several original papers were published in *Critical Care* dealing with resource management. The term 'resource management' means the efficient and effective deployment of an organization's resources when and where they are needed. Intensive care consumes a disproportionate amount of health care resources, and as these resources become increasingly constrained it is imperative that deployment of intensive care unit (ICU) resources be optimized.

With respect to appropriate allocation of ICU resources, it is clear that accurate prognostication in critical illness is of the utmost importance. Also, efforts should continue to reduce length of stay. Over recent years, the number of reports focusing on delirium has risen. Because development of delirium has a strong impact on clinical outcome, delirium influences resource management in the ICU. In the ICU setting, the rate of errors in medication prescribing is high, possibly because of the high numbers of drugs that ICU patients receive, preference for intravenous administration

and the high incidence of organ failure. It is clear that such errors also have impact on ICU resource management, and it may be possible to prevent medical errors in the ICU by using computerized physician order entry. Hospital resources should also be taken into account; for instance, a critical evaluation of the use of radiology may be warranted. Finally, optimizing ICU resource management includes not only the immediate clinical resources of the ICU and hospital but also other, less tangible factors, such as difficulties associated with obtaining and recall of having given informed consent.

Outcome prediction

Accurate prognostication in critical illness is essential for appropriate decision making, patient counselling and resource allocation. In a study comparing prognostic models for morbidity prediction after cardiopulmonary bypass surgery in an Italian hospital, Biagoli and coworkers [1] found a Bayesian linear model to have greater discriminatory power compared with simple scoring models, even when customized to a local population. Provided that computers and the required software are available in the ICU, the simplicity of scoring models must be balanced against greater discriminatory power and better calibration of more complex linear and nonlinear models.

Researchers and clinicians only recently began to conduct systematic evaluations of critical care outcomes beyond hospital and ICU mortality. A group from Slovenia compared 2-year survival and quality of life (QoL) between patients with sepsis or trauma treated in the surgical ICU [2]. Patients with trauma tended to be younger, male and more likely to be alive in the ICU, hospital and at 2-year follow up. Absolute differences in hospital mortality (62% versus 42%) and 2-year mortality (33% versus 57%) were similar, suggesting that

most of the difference in outcomes occurred during the hospital stay. QoL was similar between the two groups. Two years after critical illness, the majority of the patients had pain, symptoms of depression, or problems with usual activities.

Advances made in critical care and organ support have led to the emergence of a distinct clinical entity: 'chronic critical illness' (CCI) [3]. In a prospective observational study conducted in an Argentinean ICU [3], 12% of patients met criteria for CCI, defined as need for tracheostomy for prolonged mechanical ventilation. CCI patients were more likely to have acute respiratory distress syndrome and greater acuity of illness, but they were less likely to have significant underlying co-morbidity, and there was no difference in mortality in comparison with patients who did not meet criteria for CCI. Although the authors postulated that there was greater reserve in patients without underlying co-morbidities, conferring upon them a survival advantage, alternative explanations include the preferences of patients, families and providers for less aggressive care in the presence of significant co-morbidities. Friedrich and colleagues [4] studied risk factors for mortality in a Canadian cohort of CCI patients, which in this study was defined as having spent more than 30 days in the ICU. Although this group of patients represented only 8% of ICU admissions, they occupied 48% of ICU beds. At 6 months of follow up, 50% of patients were dead, 40% returned to a previous place of residence, and 10% resided in long-term care facilities. The main predictors of mortality were older age, presence of immunosuppression, need for mechanical ventilation for longer than 90 days, and need for vasopressor or inotropic support for more than 3 days after day 30 of the ICU stay or acute renal failure (requiring dialysis) 30 days after day 30 of the ICU stay.

In addition to structure and processes of care, monitoring of risk-adjusted outcomes represents an essential component of quality assurance in the ICU. Cockings and coworkers [5] demonstrated the feasibility of continuous monitoring of observed versus predicted mortality in a regional hospital in the UK, using an APACHE (Acute Physiology and Chronic Health Evaluation) II risk adjustment model. A risk-adjusted *P* chart allowed near real-time detection of trends in adjusted outcomes beyond two standard deviations that could represent real changes resulting from nonplanned events or planned interventions in any of the components of the health care system. Continuous monitoring of both processes of care and risk-adjusted outcomes is imperative for quality control in a modern ICU and health care system in general.

Delirium

Although a large body of critical care literature focuses on treatment of acute deterioration in vital signs, the number of reports focusing on other aspects, including cognitive dysfunction, delirium and post-traumatic stress disorder, is rising [6]. The recognition and treatment of these frequently

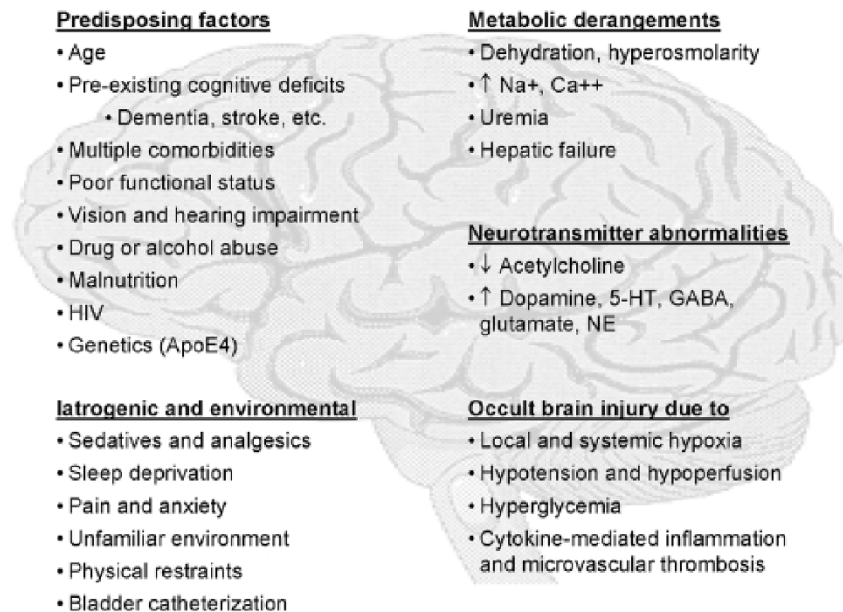
occurring psychiatric disorders is important not only to improve quality of patient care but also to improve outcome [7]. ICU physicians should view delirium, or acute central nervous system dysfunction, as the brain's form of 'organ dysfunction'. However, ICU physicians and nurses frequently only recognize the presence of a psychiatric disturbance in agitated patients, whereas the presence of a hypoactive delirium is missed [8].

The development of delirium has a strong impact on clinical outcome. Thomason and coworkers [9] demonstrated that patients who develop delirium in the ICU have a longer stay in the ICU and duration of mechanical ventilation than those who do not. These data were recently corroborated by Ouimet and colleagues [10], who showed that delirium was associated with 6 more days in the ICU and 5 more days in the hospital compared with patients who did not develop delirium during their ICU stay. This increase in consumption of hospital and ICU resources is associated with greater costs. In addition, current research indicates that long-term neurocognitive sequelae following delirium occur commonly, are underestimated and may be permanent. This impairment is associated with decreased QoL and disturbances in normal daily activities [11]. Many factors are involved in the pathogenesis of these disorders (Figure 1) [12].

Development of delirium is related to several risk factors, which can be arbitrarily grouped into patient factors, the acute illness itself and environmental factors, including drugs. Older age and male gender are well known risk factors for delirium, whereas genetic factors may prove to be important as well. Ely and coworkers [13] recently suggested that the apolipoprotein E₄ allele is a genetic factor that predisposes to longer duration of delirium. Also, delirium occurs more frequently in sicker patients and is associated with administration of lorazepam [14].

Recognition of delirium remains difficult. One of the reasons for this is the poor definition of this entity specifically in the ICU setting. Hence, a screening tool, based on established psychiatric DSM (Diagnostic and Statistical Manual of Mental Disorders) criteria, was developed that takes into account factors such as altered level of consciousness, inattention, disorientation, hallucination or delusion, psychomotor agitation or retardation, inappropriate mood or speech, sleep/wake cycle disturbance, and symptom fluctuation [15]. Later, Ely and colleagues [16] introduced and validated the Confusion Assessment Method (CAM) for ICU patients, which was simpler to use than the original CAM by taking into account problems with communication in intubated patients. This so-called CAM-ICU exhibited good inter-rater reliability and was useful in establishing the occurrence of delirium, but also in the follow-up of delirium during repeated measurements [17]. However, in nonintubated verbally communicative patients, the original CAM may be superior in detecting subtle cases of delirium [18].

Figure 1



Pathophysiological mechanisms and predisposing factors that are believed to underlie critical illness associated cognitive dysfunction. Apo, apolipoprotein; 5-HT, 5-hydroxytryptamine (serotonin); GABA, γ -aminobutyric acid; NE, norepinephrine (noradrenaline). Reproduced from [12].

The most important factor responsible for under-recognition of delirium may be that most studies have measured delirium at one point in time over a 24-hour period. Given the fluctuating nature of delirium, this approach severely limits the sensitivity of detecting delirium, because symptoms indicative of delirium occurring before or after the delirium assessment may go undetected. Incorporating chart review in the evaluation of delirium resulted in an overall incidence exceeding 80% in an ICU population older than 60 years [19].

Can the occurrence of delirium be predicted or even prevented in ICU patients? Marcantonio and coworkers [20] conducted a prospective cohort study in elderly noncardiac surgery patients and were able to develop a simple predictive rule using seven preoperative factors, including physical and cognitive function. Among elderly patients undergoing hip surgery who were at risk for delirium, prophylactic haloperidol was compared with placebo [21]. Although there was no difference in the incidence of postoperative delirium between the two groups, those in the haloperidol group exhibited significantly reduced severity and duration of delirium. We await studies aiming to achieve targeted prevention and multifactorial treatment of delirium in general critically ill patients.

Medical errors

Approximately 40,000 to 100,000 people die each year in hospitals in the USA as a result of medical errors [22]. Medication errors are estimated to account for at least 7,000 deaths each year [22]. These errors can occur at all stages of the medication process. Although most of these errors are

harmless, some do result in an adverse drug event [23]; one in 100 in-hospital medication errors result in an adverse drug event, and seven in 100 have the potential to do so [23,24]. In the ICU setting the rate of preventable and potential adverse drug events is even greater, being almost twice as high as outside the ICU setting [25]. This is possibly because of the high number of drugs that ICU patients receive, the preference for intravenous administration and the high incidence of organ failure. Such adverse events may have considerable impact on use of ICU resources.

Computerized entry of physician orders has been recommended as a major step toward improving patient safety. This is because computerized entry could eliminate many of the problems associated with manual writing of drug orders by decreasing the occurrence of illegible orders, inappropriate doses and incomplete orders.

Colpaert and colleagues [26] conducted a prospective, controlled, cross-sectional trial in two paper-based units versus one computerized unit in order to evaluate and compare the incidence and severity of medication prescribing errors between these two systems. A total of 2,510 medication prescriptions were evaluated, and 375 medication prescribing errors were identified. The incidence of medication prescribing errors was significantly lower in the computerized unit than in the paper-based unit (3.4% versus 27.0%), with fewer minor medication prescribing errors in the computerized unit than in the paper-based unit. The incidence of intercepted medication prescribing errors was

four times lower in the computerized unit than in the paper-based unit. There was also a reduction in adverse drug events (two in the in the computerized unit versus 12 in the paper-based unit).

Computerized physician order entry created new problems, such as inconsistent or duplicate orders. Causes were related to deficiencies in the computerized physician order entry system itself and to human error. Several examples emphasize that it is important to evaluate a newly installed system objectively and correct the problems encountered. One frequent error was the unnoticed changing of an already activated prescription of a continuous infusion medication. Another problem related to requests for assessment of drug plasma concentration levels; they were often being forgotten or, on the other hand, continued to be requested after the medication had been stopped.

Future research is needed to address the cost-benefit ratio of the installation of computerized order systems. At present, information regarding the cost-benefit of such systems is lacking.

Radiology resources

Chest radiographs are frequently obtained as a complement to physical examination of critically ill patients [27,28]. There are two different schools of thought regarding the utility of chest radiographs in the ICU: chest radiographs should be requested based on indication only, specifically when there is a sound reason to obtain a film (a so-called 'on demand' strategy); alternatively, chest radiographs should be obtained routinely every day, without any specific reason to do so (a so-called 'daily routine' strategy). In favour of the latter strategy is the high prevalence of pathological findings on chest radiographs in ICU patients [29]. Presently, the consensus opinion of the American College of Radiology expert panel is that daily routine chest radiographs are indicated in patients with acute cardiopulmonary problems and those receiving mechanical ventilation [30].

However, interpretation of studies on the usefulness of daily routine chest radiographs is hampered because of major differences in methodology [31]. Also, most studies did not attempt to discriminate between clinically relevant and irrelevant findings. Graat and coworkers [32] demonstrated that daily routine chest radiographs hardly ever reveal potentially important abnormalities and seldom result in a change in therapy in a mixed medical-surgical ICU. Over a 5-month period, 2,457 daily routine chest radiographs were obtained in 745 consecutive ICU patients. The majority of these chest radiographs did not reveal any new predefined major finding; on only 6% of daily routine chest radiographs (14% of patients) was one or more new and unexpected abnormality encountered, including large atelectases, large infiltrates, severe pulmonary congestion, severe pleural effusion, pneumothorax/pneumomediastinum, and malposition

of the orotracheal tube. Interestingly, fewer than half of chest radiographs with a new and unexpected finding turned out to be clinically relevant; in only 2% of all daily routine chest radiographs (6% of patients) did these abnormalities result in a change to therapy.

A recent study conducted by the same investigators [33] confirmed the findings of others [34,35]. Elimination of daily routine chest radiographs reduced markedly the number of chest radiographs (from 1.1 ± 0.3 to 0.6 ± 0.4 chest radiographs/patient per day), while not affecting readmission rates and ICU and hospital mortality rates. The reduction in chest radiographs usage equalled a cost reduction of more than €18,000 per month in this 30-bed ICU.

Informed consent

One time-consuming aspect of ICU practice is obtaining informed consent for medical interventions. Even if informed consent can be obtained, another hurdle must be address if one wishes to conduct clinical research. Researchers - academic as well as non-academic - will have to fulfil all of the new obligations now imposed by the European Union (EU) Directive on Clinical Research. It is not clear yet whether these changes will be a blessing or a curse for clinical research involving critically ill patients [36].

The EU Directive on Clinical Research (2001/20/EC) [37] was approved 6 years ago [38] and implemented in national laws of the EU member states. This has limited the ability of family members to act as legal representatives in terms of granting consent for participation in medical research involving humans where the patient is incapacitated. Specifically, that ability is restricted to the spouse or legal representative. Although the Directive was devised to protect people with chronic incapacity to make their own decisions, it also strongly influenced whether patients undergoing treatment in emergency medicine departments could be included in clinical research protocols. The medical community reacted and lobbied for different rules in relation to these acutely incompetent patients [39,40]. The same concerns applied to critically ill patients, who are frequently (temporarily) incapable of giving informed consent [41-43].

In The Netherlands, the requirements described in the Directive have been transposed into the revision of the Medical Research in Human Subjects Act and Medical Law [44]. The amended Act changes the rules governing (drug) studies in The Netherlands. However, regarding the legal representative, an amendment was made, so that - in the absence of a legal representative, spouse, or life companion - the law presently also permits parents, children, and siblings to give surrogate informed consent.

Veelo and coworkers [45] studied the effects of this revision and found that under the original EU Directive, 46% of patients would be without a legal representative; under the

new revised version of the Directive this proportion was only 8%. Older age was significantly associated with impossibility of obtaining informed consent using the original EU Directive, leading to possible bias in clinical research in critically ill patients. Only one of 211 patients (0,5%) was represented by a formal legal representative, designated in advance. Legal guardians were not found among the representatives in this series. Representatives felt very confident in how well they were able to represent the patients. In turn, patients were equally confident that their representatives were able to represent them [45].

Sometimes, ICU patients are able to give informed consent themselves, possibly as a result of lighter sedation. However, recall of participation is poor, in that only 32% of patients could recall the purpose of the clinical trial and its related risks [46]. Factors associated with complete recall were whether a patient had been able to ask at least one question about the trial or had been able to read the information leaflet.

Conclusion

In the years to come, a number of challenges in intensive care medicine will need to be addressed as society changes. The available resources for health care will remain under great pressure, risk management will increasingly require our attention, and new challenges in research will arise as a result of changes in legislation. Last year's *Critical Care* papers have provided us with a number of interesting and highly accessed original papers dealing with these issues. The information yielded by these studies may help us to deal with some of these issues.

Competing interests

The authors declare that they have no competing interests.

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